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Testbeam evaluation of heavily irradiated silicon strip modules for ATLAS Phase - II Strip Tracker Upgrade

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The planned HL-LHC (High Luminosity LHC) is being designed to maximise the physics potential of the LHC with 10 years of operation at instantaneous luminosities of $7.5x10^{34}cm^{-2}s^{-1}$. A consequence of this increased luminosity is the expected radiation damage requiring the tracking detectors to withstand hadron equivalences to over $1x10^{15}$ 1 MeV neutron equivalent per cm^2 in the ATLAS Strips system.

The silicon strip tracker exploits the concept of modularity. Fast readout electronics, deploying 130nm CMOS front-end electronics are glued on top of a silicon sensor to make a module. The radiation hard n-in-p micro-strip sensors used have been developed by the ATLAS ITk Strip Sensor collaboration and produced by Hamamatsu Photonics.

A series of tests were performed at the DESY-II and CERN SPS test beam facilities to investigate the detailed performance of a strip module with both 2.5cm and 5cm length strips before and after irradiation with $8x10^{14}neqcm^{-2}$ protons and a total ionising dose of 37.2MRad. The DURANTA telescope was used to obtain a pointing resolution of <4um, with an additional pixel layer installed to improve timing resolution to ˜25ns.

Results will show that prior to irradiation a wide range of thresholds (0.5-2.0 fC) meet the requirements of a noise occupancy less than $1x10^{-3}$ and a hit efficiency greater than 99%. After irradiation, there is still a range of thresholds near 0.5 fC that will simultaneously meet both efficiency and noise requirements with short and long strips at 500 V sensor bias.

A signal-to-noise of 10.9:1 was achieved, and is envisaged to increase to ˜17:1 with the reduction in noise in the production readout chip with the use of enclosed layout transistors in the critical regions of the front-end.

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